EXPERIMENT K-6-11

ACTIN MRNA AND CYTOCHROME C MRNA CONCENTRATIONS IN THE TRICEPS BRACHIA MUSCLE OF RATS

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INTRODUCTION

It is well known that some skeletal muscles atrophy as a result of weightlessness (Steffen and Musacchia, 1986) and as a result of hindlimb suspension (Tischler et al., 1985, Thomason et al., 1987). Because the content of protein is determined by the rates of protein synthesis and degradation, a decrease in protein synthesis rate, or an increase in the protein degradation, or changes in both could produce the atrophy. Indeed, an increased protein degradation (Tischler et al., 1985) and a decreased protein synthesis (Thomason et al., 1988) have been observed in skeletal muscles of suspended hindlimbs of rats. Any decrease in protein synthesis rate could be caused by decreases in mRNA concentrations. Such decreases in the concentration and content of alpha-actin mRNA and cytochrome c mRNA have been noted in skeletal muscles of hindlimb suspended rats (Babij and Booth, 1988). From these findings we hypothesized that alpha-actin mRNA and cytochrome c mRNA would decrease in the triceps brachia muscle of Cosmos 1887 rats.

RESULTS

Forty-two hours following the landing of a 12.5-day flight on Cosmos 1887, the wet weight of the triceps brachia was significantly less (-19%) than the synchronous control group, but was not significantly different from the other two control groups (Table I). No significant differences for the ratio of triceps brachia wet weight to body weight existed between the flight group and any control group. Also no significant differences in RNA concentration and in RNA content occurred between the flight and control groups. The quantity of alpha-actin mRNA per unit of RNA was no different between the flight group and any control group. Although the quantity of cytochrome c mRNA per unit of RNA was significantly higher in the flight group than the vivarium control group, there were no differences between the flight group and either the basal control group or the vivarium control group.

DISCUSSION

It is well known that slow-twitch muscle atrophies more quickly than fast-twitch muscle, either in hindlimb suspension or in weightlessness (Steffen and Musacchia, 1986, Thomason et al., 1987). Such an observation may explain, in part, the failure to observe atrophy of the fast-twitch triceps brachia 42 hours after a 12.5-day spaceflight. It is also possible to speculate that the triceps brachia is recruited frequently in space as the rat attempts to hold on to a position in the cage or to move between two points and that this event prevented atrophy. Electromyography of rat skeletal muscles in weightlessness is necessary to document this hypothesis. The failure to replicate observations of decreases in the quantities of specific mRNAs in skeletal muscles of hindlimb-suspended rats could be due to a number of factors. First, as discussed above, the triceps brachia did not atrophy in space whereas the skeletal muscles having decreased concentrations of alpha-actin mRNA and cytochrome c mRNA were atrophied after seven days of hindlimb suspension. Second, alpha-actin mRNA concentrations could have recovered during the 42-hour period elapsing between the end of the 12.5-day flight and removal of the muscle from the rats. Rapid recovery of alpha-actin mRNA concentrations has been noted in atrophied muscle recovering from seven days of hindlimb immobilization. The concentration of alpha-actin mRNA per unit of RNA decreased 47% in fast-twitch muscle after the seventh day of limb immobilization, but returned to control values on the second day of recovery (Morrison et al., 1987b). Thus either the 42-hr recovery of skeletal muscle from weightlessness or the lack of atrophy could explain the observation of no change in alpha-actin mRNA quantities. The failure to observe a significant decrease in cytochrome c mRNA in the triceps brachia muscle is likely related either to the absence of atrophy or to a speculated absence of a decline in the electromyographic activity of the triceps brachia muscle. It is unlikely that the 42-hour recovery period following the return from weightlessness was the explanation for no change in cytochrome c mRNA in the triceps brachia muscle because cytochrome c mRNA did not recover for the first 2 days after ending seven days of limb immobilization (Morrison, et al., 1987a). Rather, it took four days of recovery for cytochrome c mRNA to increase from 60% of control to 126% of control values in fast-twitch muscle after the limb immobilization.

CONCLUSION

The triceps brachia was not atrophied after 42 hours of recovery from 12.5 days in space. Both of these factors (lack of atrophy and recovery time) likely contributed to the lack of change in RNA content and alpha-actin mRNA concentration per unit of RNA. A speculated maintenance of electromyographic activity by the triceps brachia while in space likely contributed to the absence of any change in cytochrome c mRNA in this muscle.

ACKNOWLEDGMENTS

We thank Dr. Richard Grindeland for his support and Dr. V.S. Oganov for the supply of tissue. The research was supported by NASA grant NAG 2-239.

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TABLE 1

TRICEPS BRACHIA(n=5) AMONG 4 GROUPS ANOVA, P=

	GROUP				
Measurements	Flight	Basal	Synchronous	Vivarium	Among 4 Groups ANOVA, P=
Muscle wet wt (MW) (g)	1.28±0.20	1.38±0.13	1.52±0.11*	1.51±0.15	0.063
MW/Body Weight (g/g)	0.42±0.07	0.44±0.07	0.44±0.05	0.44±0.07	0.917
RNA Concentration (mg/g muscle)	1.03±0.08	1.05±0.19	1.08±0.13	1.01±0.08	0.856
RNA Content (mg/whole muscle)	1.32±0.28	1.47±0.39	1.65±0.24	1.53±.23	0.396
ACTIN mRNA slope (DPM/µg RNA)	1686	2186	1732	1408	0.046
CYT. c mRNA slope (DPM/µg RNA)	97	97	73	74*	0.051

Values are means ± SD
* indicates P<0.05 from flight group